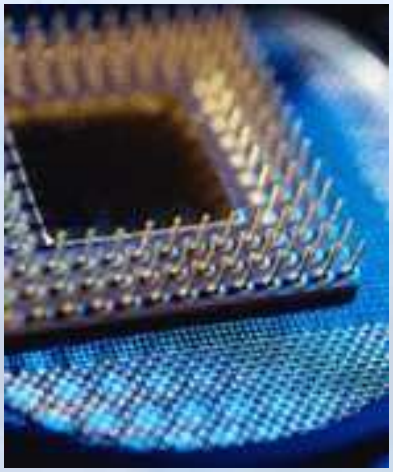
AB 32 Discrete Early Action Measure

Semiconductors and Related Devices
Fourth Public Workshop



California Air Resources Board
Sacramento, CA
October 23, 2008

California Environmental Protection Agency
AIR RESOURCES BOARD

Outline

- Applicability
- Proposed Performance Standards
- Calculation Method
- Emissions and Emission Reductions
- Reporting and Recordkeeping
- Schedule

Applicability

- Semiconductors and related devices
  - products include semiconductor diodes, zeners, stacks, rectifiers, integrated microcircuits, transistors, solar cells, light-sensing devices, and light-emitting devices
- Operations using fluorinated gases include:
  - semiconductor manufacturers
  - research and development
  - tool makers
  - universities

Review of Proposed Performance Standards (Semiconductor and Related Devices) Effective 1/1/2012

CVD Chamber Cleaning and Etching Processes	
Category (Million Sq Cm Per Calendar Year)	**Maximum Emissions Per Square Centimeter for a Calendar Year** (Kg CO_2e/cm^2)
Tier 1: >37.7	0.20
Tier 2: >3.7 and ≤37.7	0.30
Tier 3: ≤3.7	0.50

Calculation Method
Overview

- Calculate emissions in Kg using IPCC Tier 2b method
  - process specific
  - includes by-products
- Convert Kg to CO_2e
  - multiply each gas by its GWP value
- Calculate total sq cm of wafers per year

2006 IPCC Report

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories Report
  - 2006 IPCC Tier 2b Method (equation 6.7)
  - By-Product Equations (6.2 – 6.6)
  - Industry-wide Default Values (such as heel, DRE)

- Website for report:

  http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_6_Ch6_Electronics_Industry.pdf

Sample Calculation for Company X

- Outline
  - Fluorinated gas use in kilograms
  - Fluorinated gas emissions in kilograms
  - Total emissions in MMT CO_2e
  - Emissions per sq cm of wafer produced

Company X Fluorinated Gas Usage (Kg)

Gas	CVD Chamber Cleaning (CVD)	Etching	CVD + Etching
C_2F_6	1,500	0	1,500
C_3F_8	0	0	0
CF_4	1,000	700	1,700
CHF_3	0	500	500
$c\text{-}C_4F_8$	200	600	800
C_4F_8O	150	0	150
C_4F_6	0	100	100
NF_3	900	1,000	1,900
SF_6	0	800	800
Total	**3,750**	**3,700**	**7,450**

Default Values and Emission Estimates[b,c] (E_i) in Kg (CVD Chamber Cleaning Process)

Gas	1-Ui Default	B_{CF4} Default	Destruction Removal Efficiency (DRE) Default	Ei (Kg)
C_2F_6	0.6	0.1	0.9	520
C_3F_8	0.4	0.1	0.9	0
CF_4	0.9	NA	0.9	446
CHF_3	NA	NA	0.9	0
c-C_4F_8	0.1	0.1	0.9	20
NF_3	0.2	0.1	0.95	---
NF_3 Remote	0.02	0.02	0.95	17
SF_6	NA	NA	0.9	0

Footnotes: [b] **2006 IPCC Tier 2b Method** [c] **50% of gas abated in CVD chamber cleaning process and with remote plasma for Company X**

Default Values and Emission Estimates[b,c] (E_i) in Kg (Etching Process)

Gas	1-Ui Default	B_{CF4} Default	B_{C2F6} Default	DRE Default	Ei (Kg)
C_2F_6	0.4	0.4	NA	0.9	0
C_3F_8	NA	NA	NA	0.9	0
CF_4	0.7	NA	NA	0.9	243
CHF_3	0.4	0.07	NA	0.9	116
c-C_4F_8	0.2	0.2	0.2	0.9	178
NF_3	0.2	NA	NA	0.95	---
NF_3 Remote	NA	NA	NA	0.95	473
SF_6	0.2	NA	NA	0.9	79

Footnotes: [b] **2006 IPCC Tier 2b Method** [c] **50% of gas abated in etching process and with remote plasma for Company X**

Emission Estimates[b,c] (E_i) in Kg
(CVD Chamber Cleaning and Etching Processes)

Gas	CVD Chamber Cleaning	Etching	CVD + Etching
C_2F_6	520	0	520
C_3F_8	0	0	0
CF_4	446	243	689
CHF_3	0	116	116
c-C_4F_8	20	178	198
NF_3 Remote	17	473	490
SF_6	0	79	79

Footnotes: [b] **2006 IPCC Tier 2b Method** [c] **50% of gas abated in CVD chamber cleaning and etching processes and with remote plasma for Company X**

Emission Estimates[d] (MMT CO_2e)

	CVD Chamber Cleaning	Etching	CVD + Etching
Emissions	**0.0081**	**0.0145**	**0.023**

Footnote d: Total Emission Estimates in MMT CO_2e

$= \sum [E_i(GWP_{100})_i/10^9]$

Where:

E_i = the emissions in kilograms for a given gas

i = the fluorinated gas

GWP_{100} = IPCC 100-Year Global Warming Potential (GWP) values

10^9 = the number of kilograms per million metric tons

Wafer Production for Company X[1]

Wafer Size and Number of Wafers Produced		Wafer Production in Sq Cm for a Calendar Reporting Year[a]
150 mm	200 mm	
10,000	200,000	64,599,150

Footnotes:

(1) Wafer size in millimeter (mm) = diameter of wafer

(a) Wafer Production in Sq Cm = $\sum[(\pi r_n^2 Wf_n)/100)]$

Where:

π = 3.1416

r_n = radius = one half the diameter in millimeters of a given size wafer

n = diameter of a wafer in millimeters

Wf_n = the number of wafers of a given size manufactured in the calendar reporting year

100 = the number of square millimeters per square centimeter

Company X Emissions

Emissions Estimate (Kg CO_2e)	Annual Wafer Production	Emissions
CVD + Etch	Sq Cm	Kg CO_2e Per Sq Cm
23,000,000	64,599,150	0.35

Note: 0.023 MMT CO_2e = 23,000,000 Kg CO_2e

Emissions and Emission Reductions

CVD Chamber Cleaning and Etching Processes

Category	Number of Operations	Emissions ($MMTCO_2e$)	Percent Complying Market Share	Emission Reductions ($MMTCO_2e$)
Tier 1	5	0.17	57	0.10
Tier 2	11	0.08	43	0.03
Tier 3	12	0.02	42	<0.02
Reporting Only	57	0.02	NA	NA
Total	**85**	**0.29**	**NA**	**0.15**

Survey Summary

Category	Number of Operations	Type of Operation	Wafer Sizes and Number of Operations	Gas Purchased in 2006 (Kg)
Tier 1	5	All Mfg.	150 mm – 3 200 mm – 2	49,868
Tier 2	11	4 Mfg. 7 Mfg. & R&D	<150 mm – 1 150 mm – 8 200 mm – 1 200 & 300 mm - 1	26,670
Tier 3	12	7 Mfg. 5 Mfg. & R&D	<150 mm – 1 150 mm – 10 150 & 200 mm - 1	8,971
Reporting Only	57*	17 Mfg. 12 Mfg. & R&D 18 R&D only 3 univ. 1 other	<150 mm – 6 150 mm – 22 50 & 200 mm - 1 200 mm – 3 200 & 300 mm - 3 150, 200, & 300 mm – 1	14,623 **Total 100,132**

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***May not sum to 57 as some info is unavailable and other info covered by parent company.**

Reporting

- **Initial Reporting Requirement**
  - Monthly and annual emissions for 2010, due March 1, 2011
- **Annual Emissions Reporting**
  - Submit March 1st of each calendar year
  - Contents (monthly and annual figures):
    - Fluorinated gas volumes (Kg)
    - Wafer production in square centimeters
    - Tier 2b emissions
    - Heat transfer fluid (HTF)

Reporting (cont'd)

- Includes operations that emit 0.0008 million metric tons or less of CO_2e per year
  - Primarily research and development operations
  - Excludes reporting on wafers manufactured

Recordkeeping

- Monthly fluorinated gas usage and HTF purchase/usage volumes and dates, 3 years
- Emission equipment malfunctions or failures, 3 years

Schedule

- Staff report release: January 5, 2009
- Board Hearing: February 26, 2009
- Regulation legally effective: January 1, 2010
- Compliance by January 1, 2012

Reminder

- Today's presentation is posted at:

  www.arb.ca.gov/cc/semiconductors/meetings/meetings.htm

- The semiconductor list serve is at:

  www.arb.ca.gov/listserv/semiconductors.htm

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Questions and Comments?